Free to Fly:

A story about a bitter tasting butterfly and a poisonous plant.

Julie Basu


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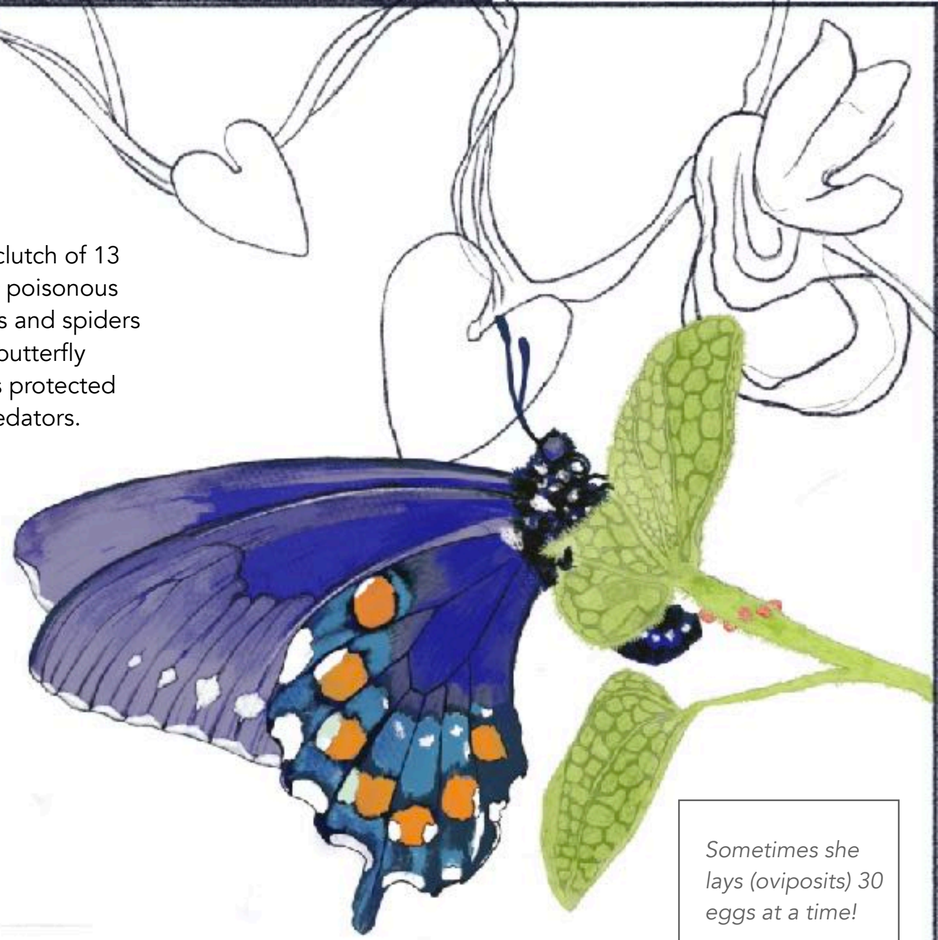
Gliding through dappled sunlight, our butterfly searches for the poisonous pipevine plant.

Most herbivores do not eat this poisonous plant with its heart-shaped leaves and strange, pipe-shaped flowers. **But when she was a caterpillar, she ate only this plant.**

The butterfly is looking for pipevine which grows along creeks and streams. This plant is the only food for the caterpillar. In fact, the entire lifecycle of the pipevine swallowtail is dependent on the caterpillar eating this plant.

Today she lays a clutch of 13 eggs on the hairy poisonous stem. Hungry ants and spiders often carry away butterfly eggs. But she has protected her eggs from predators.



Sometimes she lays (oviposits) 30 eggs at a time!

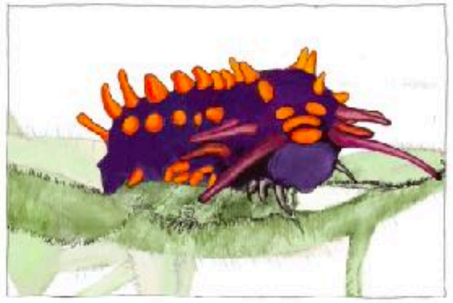
Butterfly coats her eggs with a red, bumpy, bitter coating. These bitter compounds come from the pipevine she ate as a caterpillar and now she uses these compounds to protect her eggs. Once hatched, her caterpillars crunch and chew their shells and munch together on the plant.

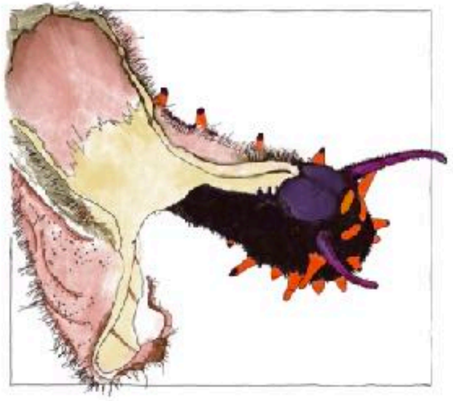
The poisons are sequestered (isolated) away from her delicate organs. The name of the poisons are aristolochia acids named after the genus Aristolochia.

Her tiny munchers eat the young tender leaves at the tips of the vine becoming more and more bitter tasting as they munch. The new leaves are the most bitter, but the little munchers are unharmed by the plant.

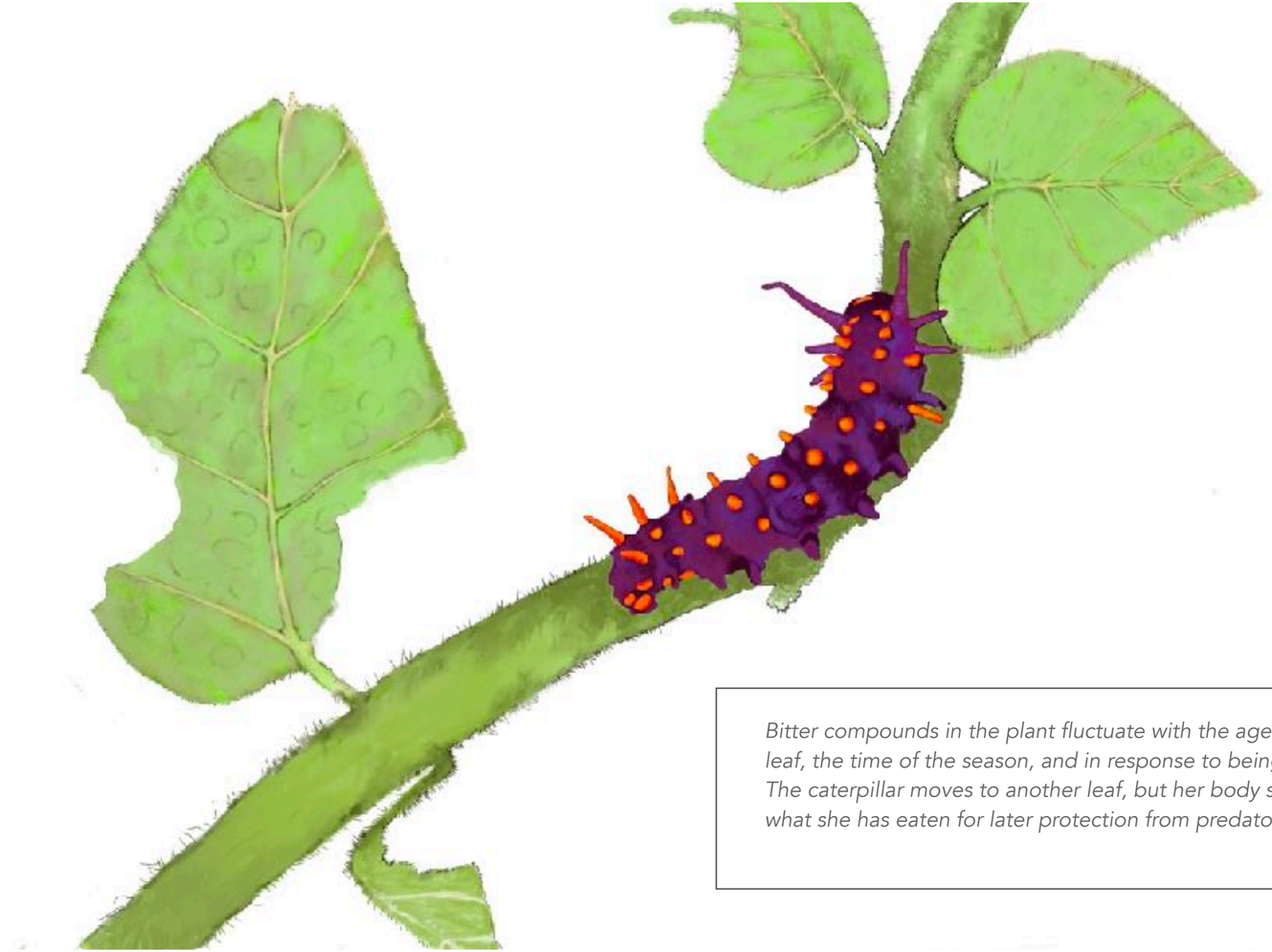
Their orange and black color warns predators that they are poisonous! There is safety in numbers and a group of poisonous caterpillars is best avoided.

(Don't tell the predators, but the caterpillars are very gentle.) Pipevine swallowtail caterpillars are gregarious (social) while they are young.



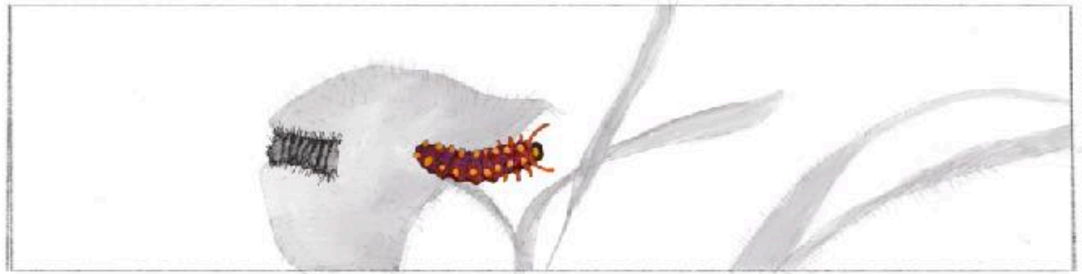


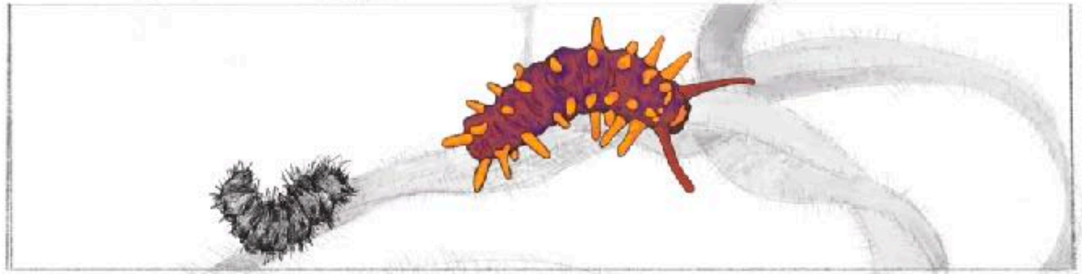
The plant can also protect itself. Sensing damage to a leaf, the plant responds with a chemical reaction that makes the damaged leaf tougher to chew. So her caterpillars move on to find new leaves to munch.

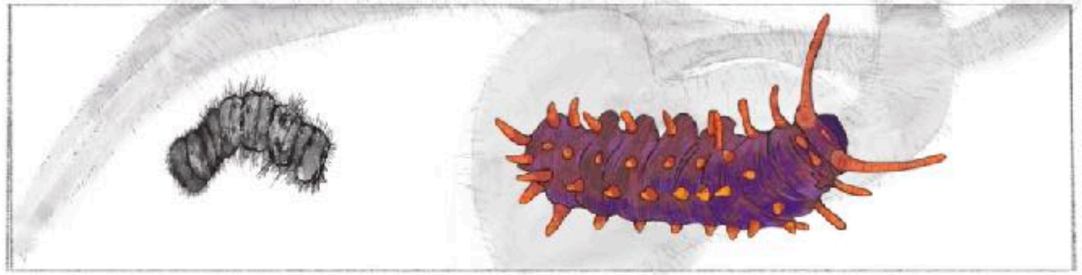


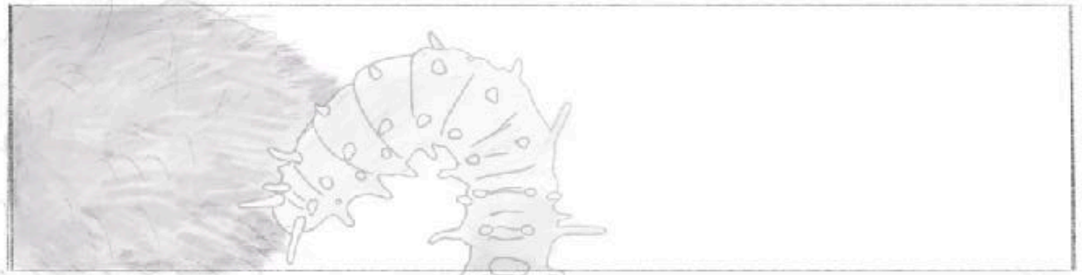
Bitter compounds in the plant fluctuate with the age of the leaf, the time of the season, and in response to being eaten. The caterpillar moves to another leaf, but her body stores what she has eaten for later protection from predators.

BUT, this pipevine swallowtail caterpillar can still be eaten by bold predators like certain birds, lizards, mice, and wasps that can withstand her poison. When threatened, she raises her osmeterium (oz - mi - teer - ee - uhm) like angry orange horns to scare away this would-be attacker.



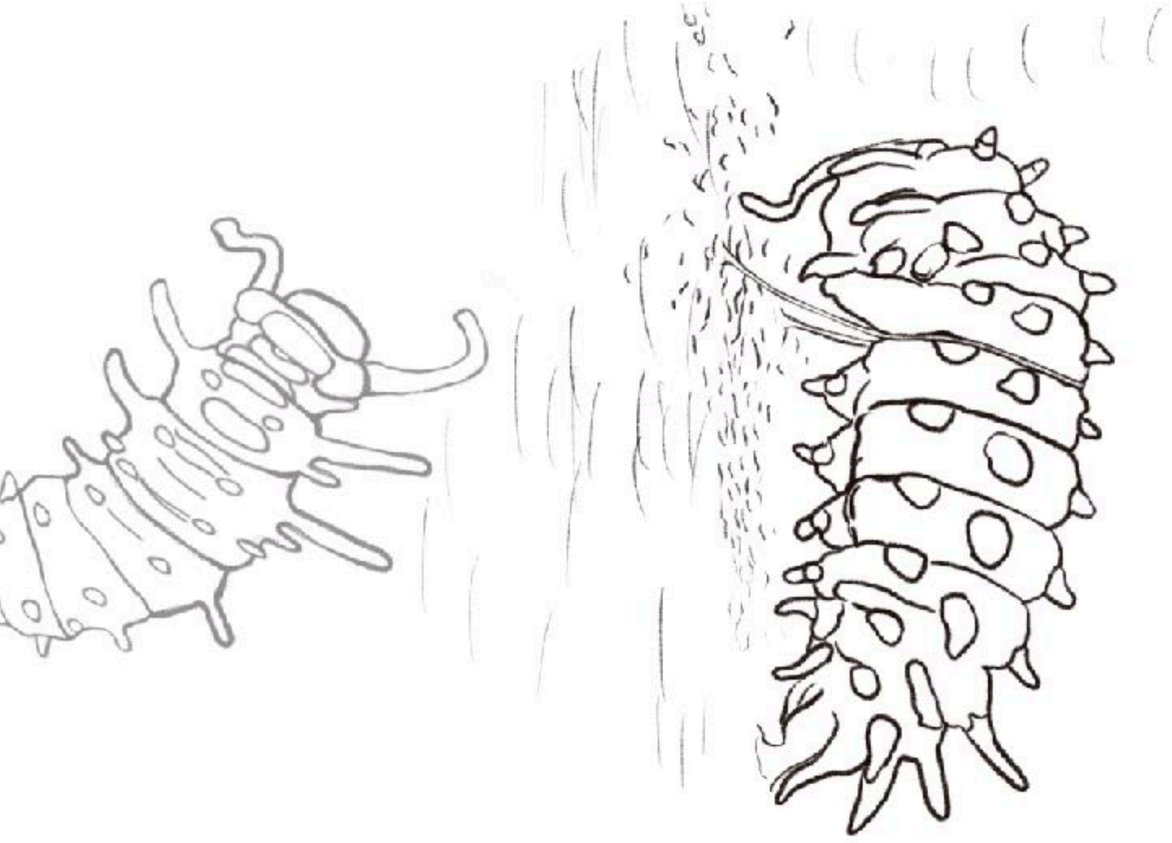






Her job as a caterpillar is to
eat and grow,
Eat and Grow,
EAT and GROW.
But her top layer of skin is now TOO TIGHT,
so she sheds it by molting.
Underneath there is a roomier layer of skin that
allows her to munch more and GROW larger.

She will molt five times while she is a caterpillar. She stores the fat and bitter compounds for the future.



As big as she can get, she finds a good sturdy spot and attaches herself with silk threads. This last molt reveals her now as a pupa (pyoo puh). Markings on the outside of the pupa look like a strange face to some. In the privacy of this pupa her body breaks down and rebuilds itself into a butterfly.

She looks completely enclosed but along the sides there are small breathing holes called spiracles that she uses to regulate her temperature and moisture.

The pupa can form in a range of colors from a dull brown to a vibrant green. This often depends on the surrounding environment; they can match green if they attach to green plant material and brown if they attach to wood or rock.

This pupa is a life stage, no longer a caterpillar and not yet a butterfly. The pupa of a butterfly can also be called a chrysalis. But a pupa is not a cocoon. Some insects make a cocoon around themselves before they molt and reveal a pupa. The pipevine swallowtail pupa is not concealed in a cocoon. Some pupa's hatch in two weeks, some go into diapause (a kind of hibernation) hatching later that year, and some wait out the winter as a pupa, hatching the following spring. Some swallowtails have been known to hatch out of their pupas after five or more years!

She emerges as a butterfly! She pumps fluid through her wings to expand them. She will remain vulnerable, lacking an escape until her wings are ready. Her wings will have to harden before she can fly. She stays very still…

Our skeleton holds up our body from the inside, but an insect's exoskeleton is actually on the outside made of layers of chitin. Chitin is the building material that makes an exoskeleton. Chitin is similar to keratin, a flexible and strong building material used for finger nails, hair, and reptile scales. Even a butterfly's wings are made of chitin only a couple of cells thick.

As a butterfly she has a proboscis (a straw-like mouth for drinking).
Butterflies can live from 2 - 5 weeks from the time they emerge from their pupa.

Finally free to take flight, she searches for mates to fertilize her eggs. She is attracted by the shimmery blue and green colors on the male's wings.

The male pipevine swallowtail is more vibrant than the darker female. Color is made two ways on butterfly wings. Either the scales (yes scales!) have pigment or they have tiny structures that reflect specific colors of light.

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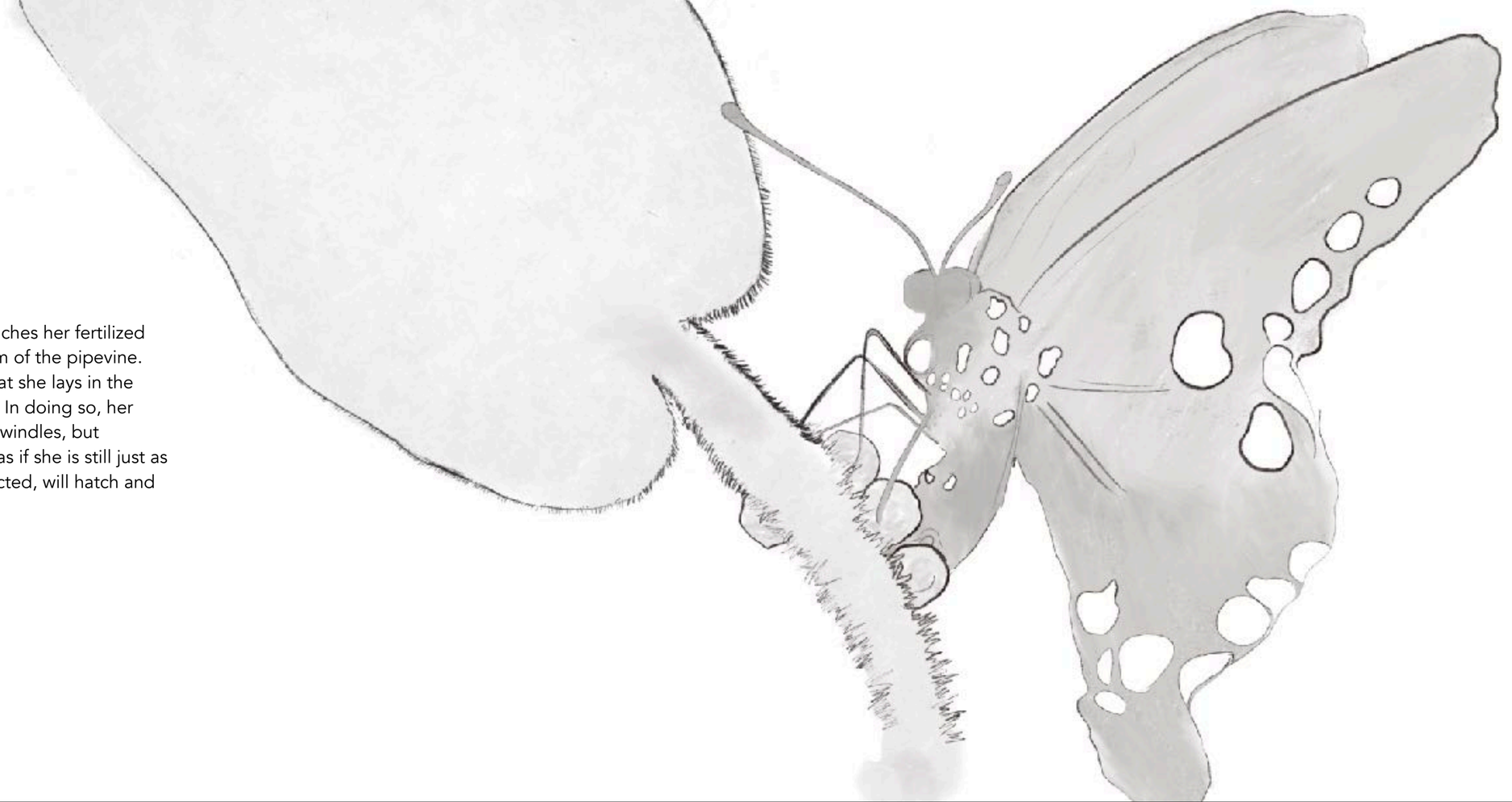
Just like her mother did, she attaches her fertilized eggs to the hairy, poisonous stem of the pipevine. She coats each clutch of eggs that she lays in the same red, bumpy, bitter coating. In doing so, her amount of chemical protection dwindles, but predators continue to avoid her as if she is still just as poisonous. Her eggs, now protected, will hatch and continue the cycle.



Notes:

Auto-mimic - is when a creature mimics better defended members of its own species. The female pipevine swallowtail is suspected to be an auto-mimic later in her life. After coating her eggs, most of her toxins are used up. Some toxins still remain in her exoskeleton, so she is not completely without protection.

Coevolution - The plant and the insect become more toxic due to pressures from both sides. The increasing bitterness of a pipevine plant forces the pipevine swallowtail caterpillar to adapt for survival. And caterpillars' munching forces the pipevine plant to protect its leaves with increasing bitterness. The two are in lockstep, exerting pressures on each other that require them to change both in the short term and over generations for survival.

Because of the bitter toxins, both the plant and insects are less likely to be eaten. But there are some herbivores and some predators who find both pipevine and pipevine swallowtails edible.

About the illustrations: There are multiple *Aristolochia* plants that serve as hosts for pipevine swallowtails. But there was never any question of which I would depict to tell this story. I chose my local pipevine plant *Aristolochia californica* and the local butterfly *Battus philenor hirsuta's* because these two have a special story to tell. Both plant and insect are endemic to Northern California and both have recently been repopulated in the San Francisco area! Their existence in San Francisco tells a beautiful comeback story thanks to Timothy Wong (a local biologist) and the many volunteers who have and are still working on this project.
Depending on where you live, your pipevine plant might be somewhat different! Also, your butterfly might be a little larger, my local subspecies is slightly smaller. (And hairier!) Check your local library to figure out which species are closest to your home.

Endemic - is a species or subspecies is found only in one location. Northern California is *Battus philenor hirsuta's* only home making it endemic. *Aristolochia californica* is only found in Northern California, making it also endemic. Since the range of this plant is limited and since this plant is the only host for the California pipevine swallowtail, efforts to propagate and grow the plant are directly helping the butterfly.

Why is *Battus philenor hirsuta* is a subspecies? There is a mountain range that is generally not crossed by butterflies, so once on the west side of the Sierras, *Battus philenor* was geographically isolated. The population that did end up on the west side of the Sierras (in Northern California) has been isolated for long enough to have changed and it is now considered a subspecies. The subspecies, *Battus philenor hirsuta* is smaller and hairier than *Battus philenor*. (The name hirsuta comes from the Latin name for hairy.)
Different species of *Battus* and *Aristolochia* can be found throughout the Americas. Related genera are also found in Asia, Oceana, and one in Madagascar. Which pipevine butterflies are near your home?

Acknowledgments:

I am grateful to the Botanical Gardens in San Francisco where I saw and photographed my first pipevine swallowtail. These photos became references for the illustrations in this book.

A huge thank you to Professor James A. Fordyce who has expanded my understanding of this subject with his careful edits and explanations.
Thank you to Professor Arthur Shapiro for making my information more accurate and for the awesome resources that you make available to people like me who are curious.
Thank you to Timothy Wong for repopulating the endemic pipevine plant and insect in the San Francisco Botanical Gardens and surrounding area! And thank you to all of the volunteers who helped him to do that. Thank you to Timothy Wong also for answering my questions and for being an inspiration!

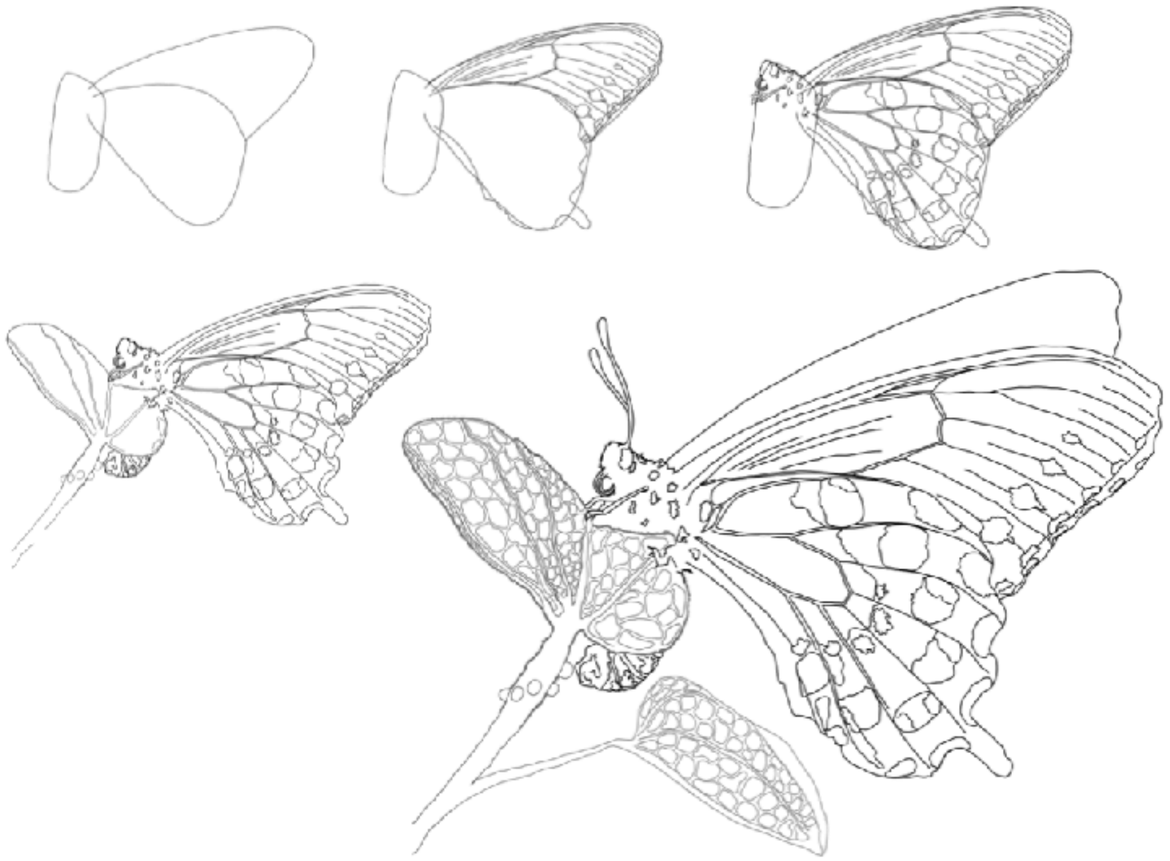
Further Reading

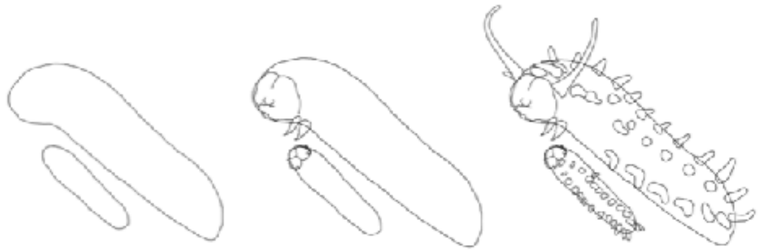
Books:
Shapiro, Arthur, and Manolis, Timothy D. Field Guide to Butterflies of the San Francisco Bay and Sacramento Valley Regions (Volume 92) (California Natural History Guides)
University of California Press, 2007.

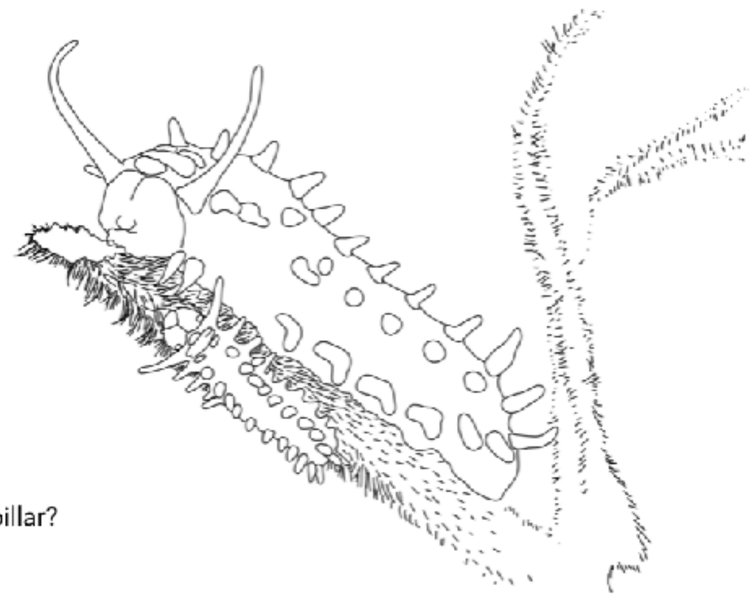
Online resources:
Art Shapiro's Butterfly Site. https://butterfly.ucdavis.edu/

iNaturalist. https://www.inaturalist.org/

In-depth sources
Sources that I read while learning about this subject are listed on my website under butterfly reading. (I still need to set a page of sources and link to it, including the link here. Include pupa times (shapiro), auto-mimic articles (Professor Fordyce and Shapiro), local articles about repopulation done by T. Wong.

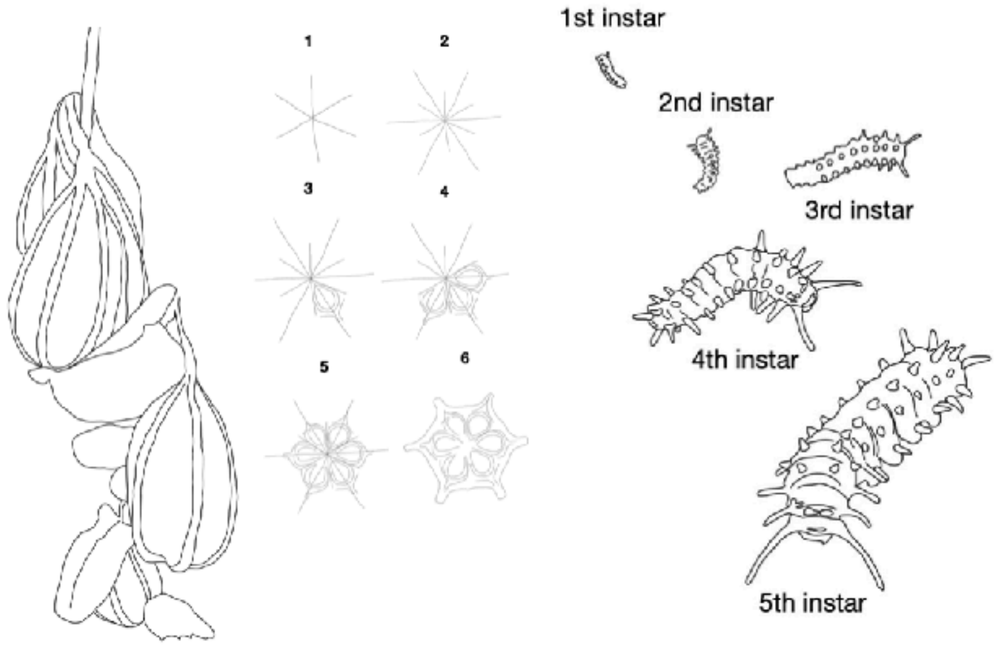




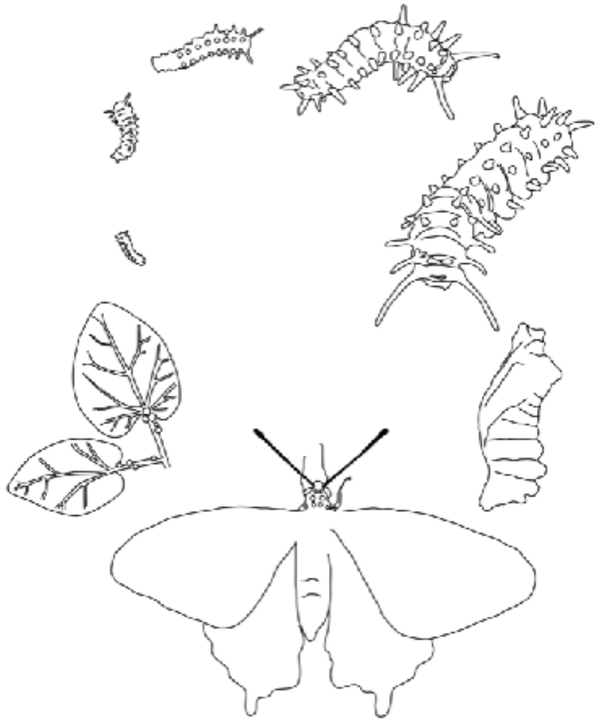


Would you like to
practice drawing
butterfly or caterpillar?

How about trying to draw pipevine seeds or the life stages (instars) of the caterpillar? A caterpillar is at a new stage of development or instar each time it molts and gets bigger?



Would you like to draw the lifecycle of the pipevine swallowtail? What insects can you find to draw in your area?



Caterpillar eating pipevine flower

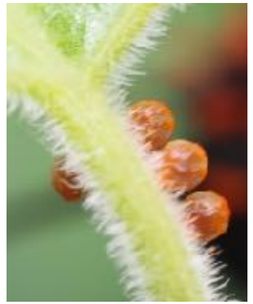
Caterpillar securing itself to a structure

Pupa green variation

Pupa brown variation

Two generations of caterpillars munching together

Tattered lated season male butterfly



Coated eggs on pipevine

(photos of the pipevine swallowtail (Battus philenor hirsuta) and pipevine (Aristolochia california) taken at the San Francisco Botanical Garden)